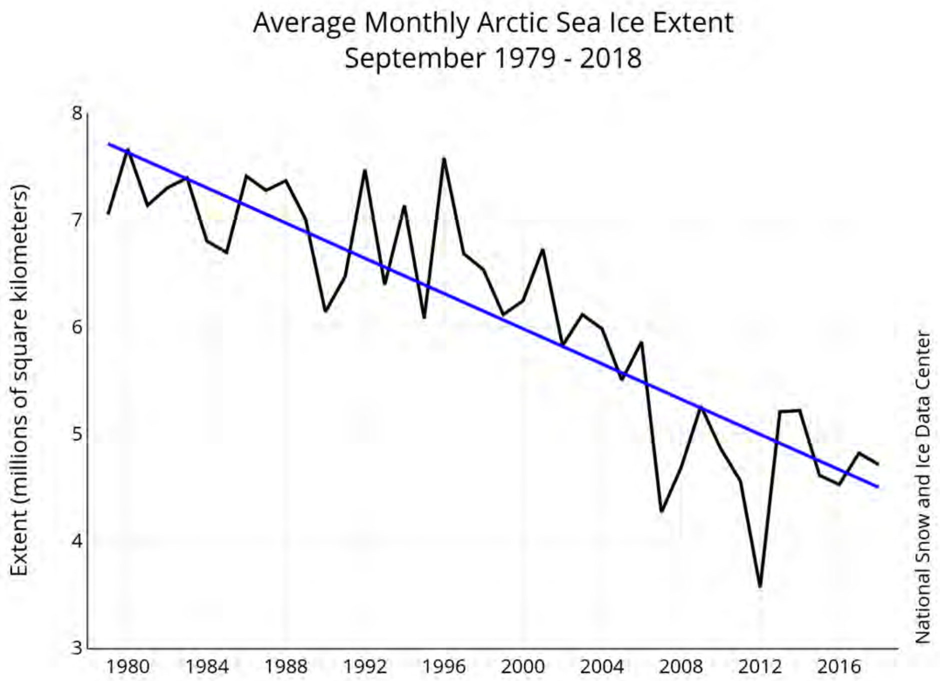
Arctic Sea Ice Prediction and Predictability

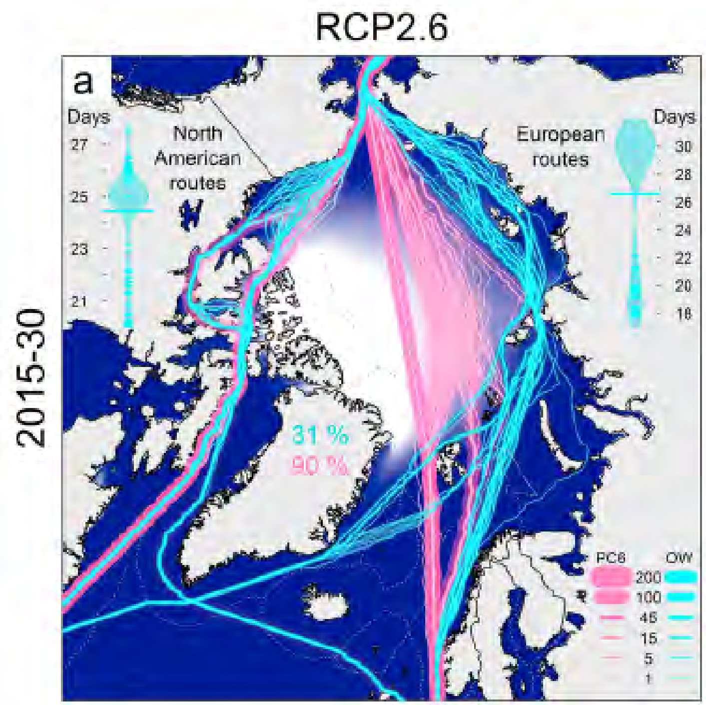
Presented by: Mitch Bushuk

Geophysical Fluid Dynamics Laboratory Review

October 29-31, 2019

Need for Seasonal Sea Ice Predictions in a Changing Arctic



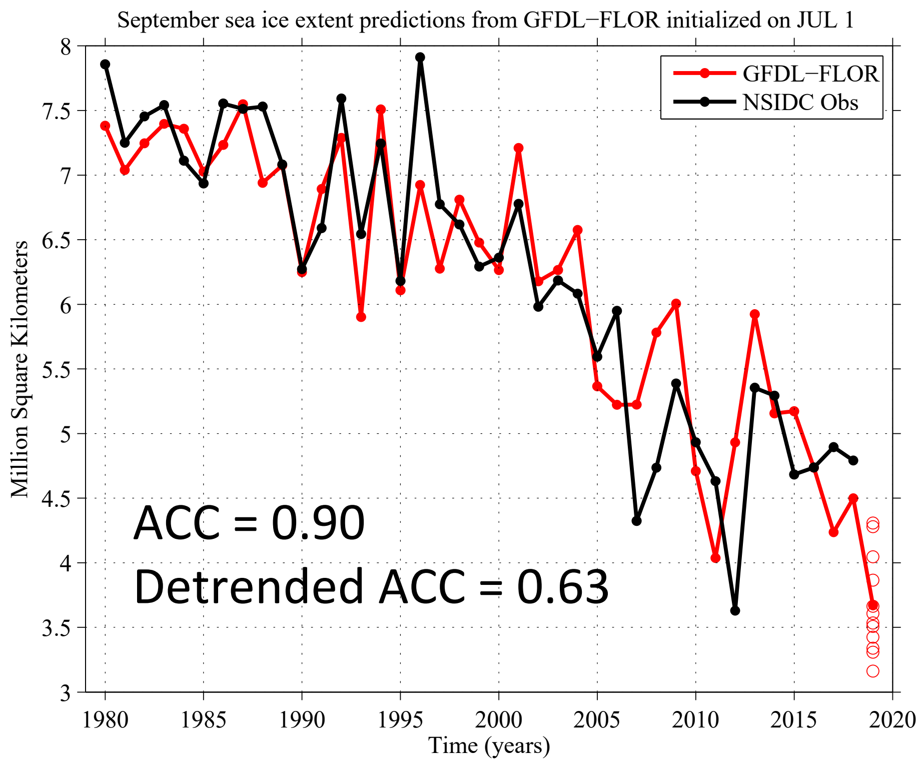


Melia et al. 2016, *GRL*

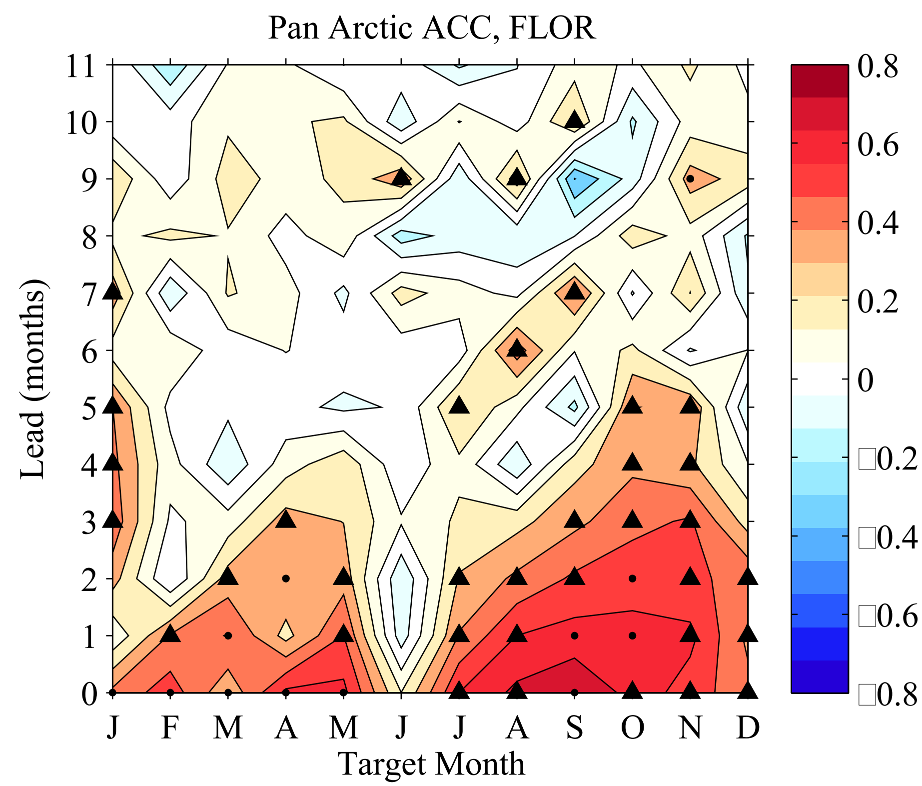
- Sea ice predictions are needed by: northern communities, shipping industries, fisheries, ecotourism, oil and gas industries, scientific logistics, wildlife management

Skillful Seasonal Predictions of Arctic Sea Ice

September Predictions; Lead 2 months



All target months, leads 0-11 months

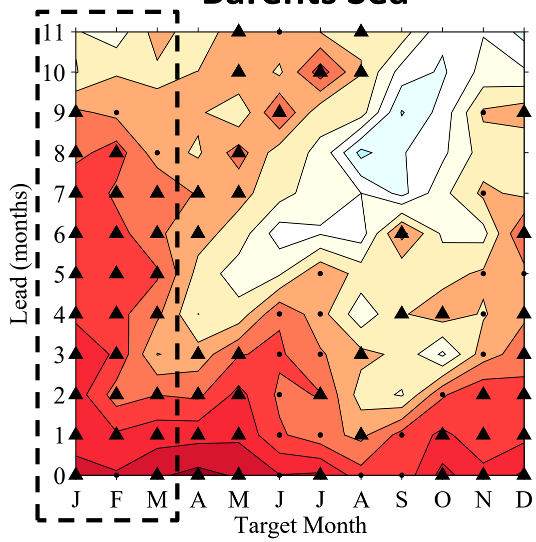


- Retrospective seasonal forecasts made with GFDL-FLOR spanning 1980-2019
- Initialized via **E**nsemble Kalman Filter **C**oupled **D**ata **A**ssimilation (ECDA)
- September sea ice extent predictions submitted to the "Sea Ice Outlook" since 2014
- Sea ice predictions submitted each month to "Extended SIPN" since 2018

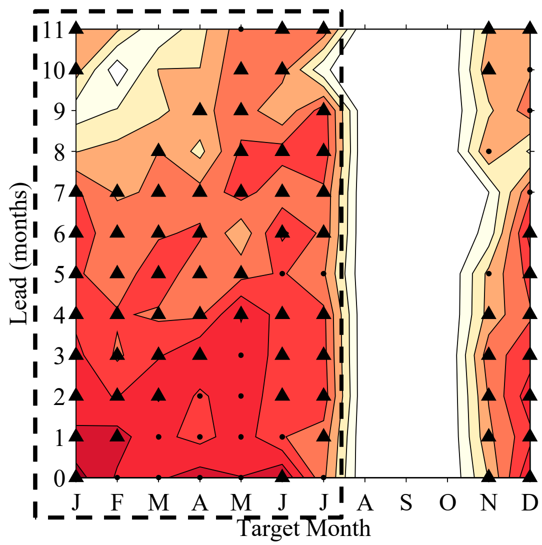
Msadek et al. 2014, *GRL*; Bushuk et al. 2017, *GRL*

Regional Prediction Skill For Winter Sea Ice

Barents Sea

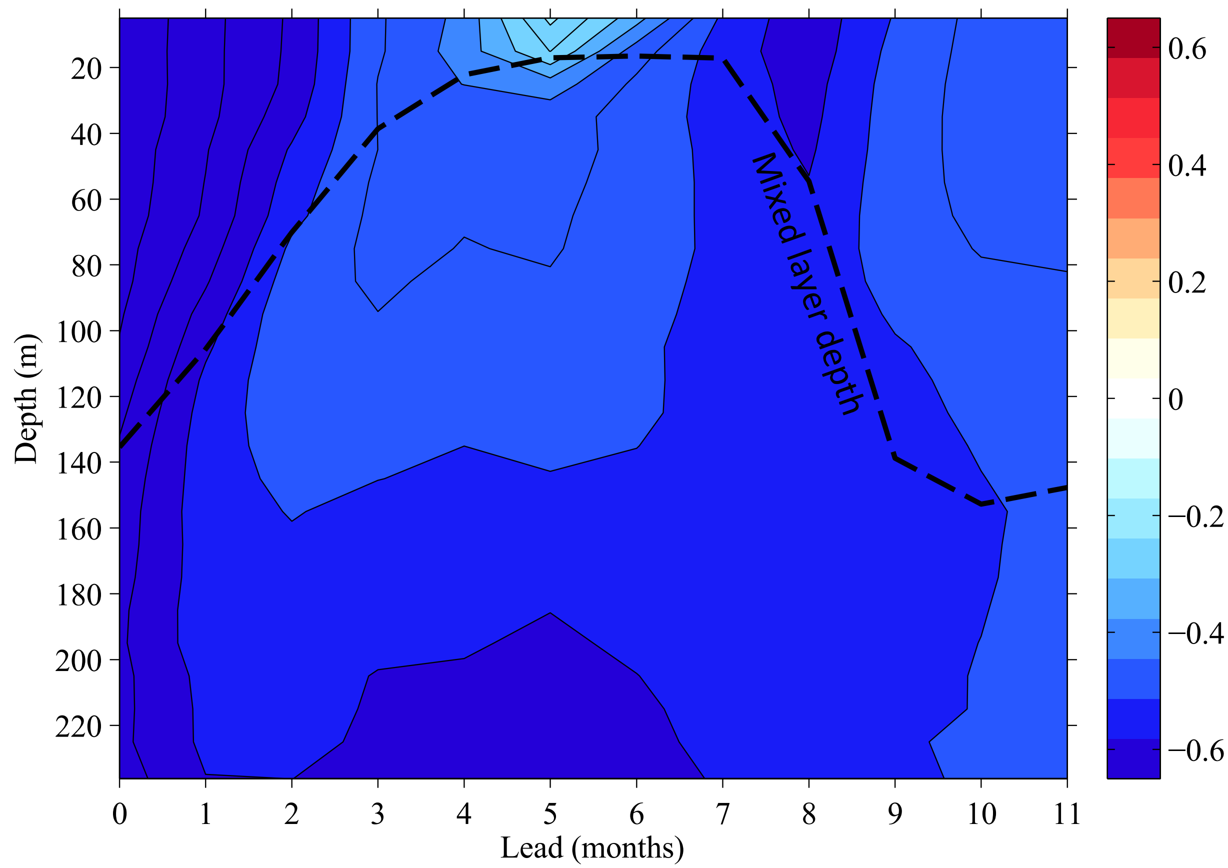


Labrador Sea



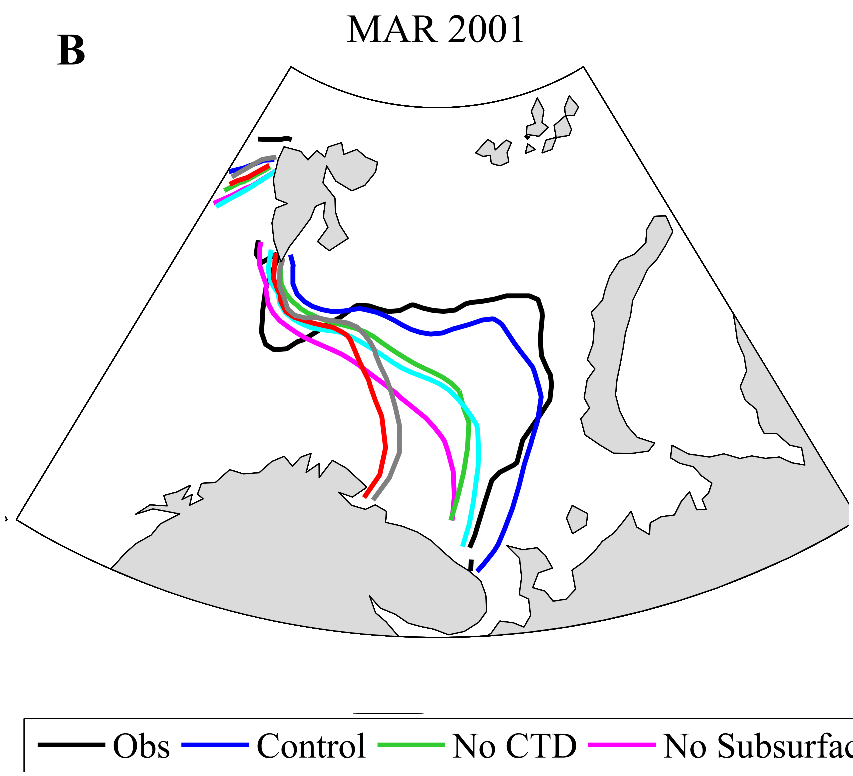
- Subsurface ocean temperature initialization provides key source of winter prediction skill

r(Observed Barents SIE_{Jan}, Ocean Temperature $IC_{Jan\ —\ lead}$)



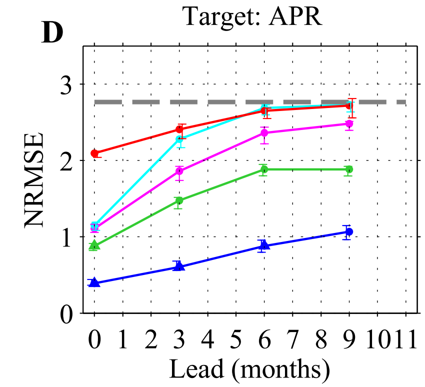
Importance of Ocean Observations

Observing System Experiments (OSEs) to quantify value of different classes of oceanic and atmospheric observations



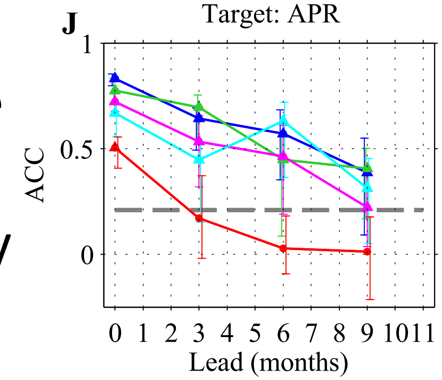
<u>Total NRMSE</u>

CTD data provides improvements in climatology



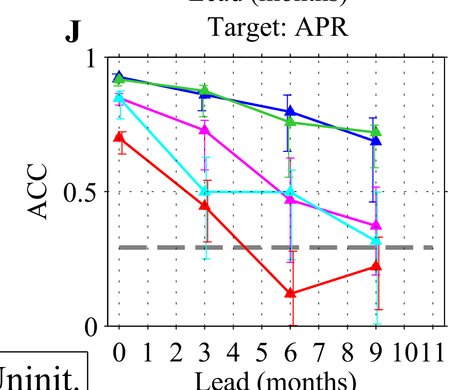
<u>Detrended ACC</u>

SST data provides the key source of interannual variability



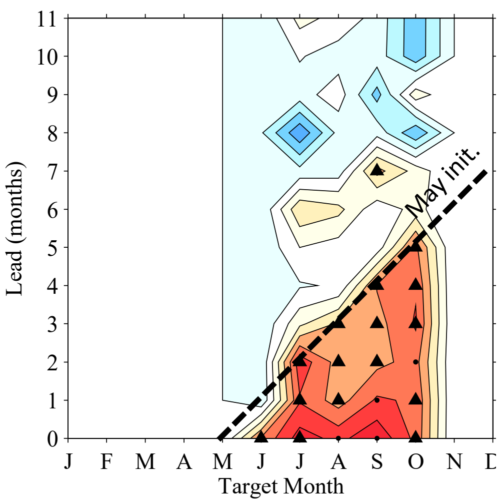
<u>Total ACC</u>

Argo and XBT data provides improved trends

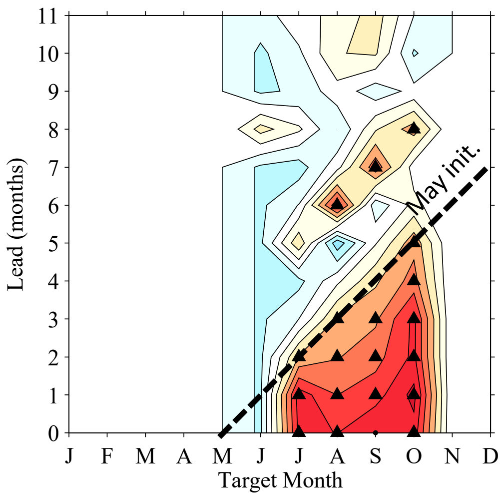


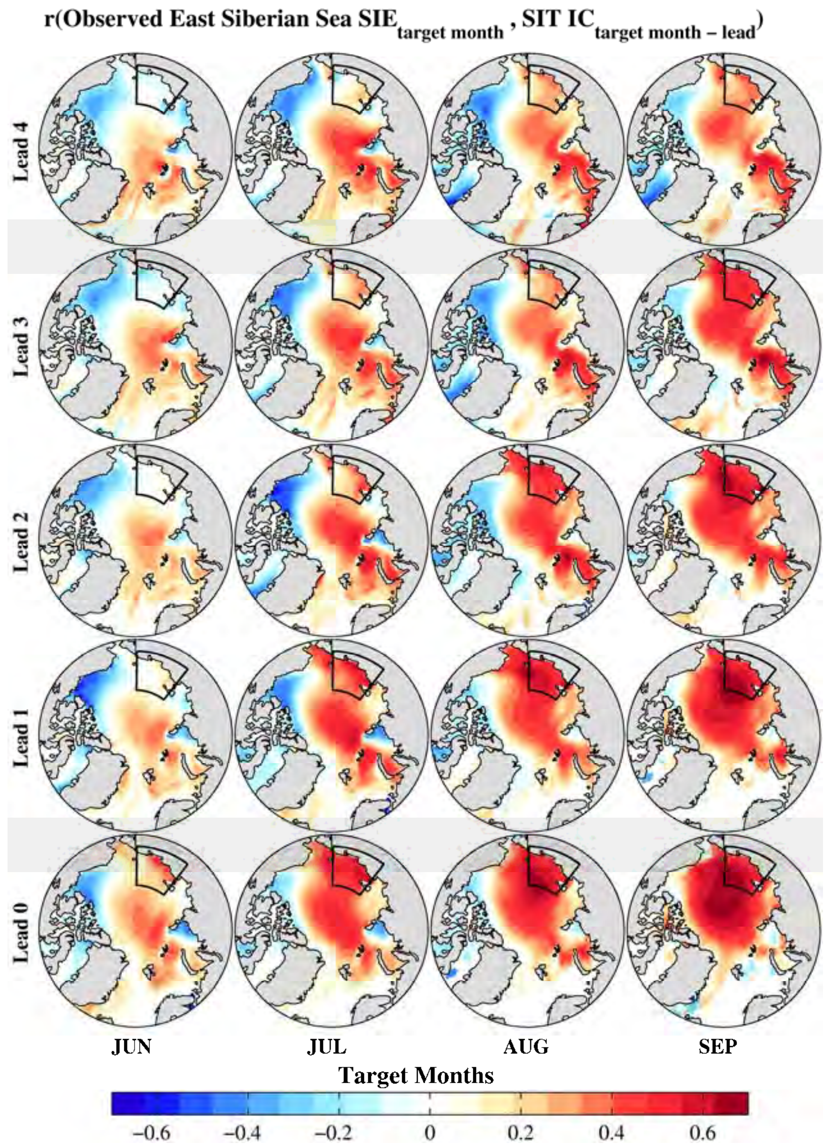
Regional Prediction Skill For Summer Sea Ice

Laptev Sea



East Siberian Sea

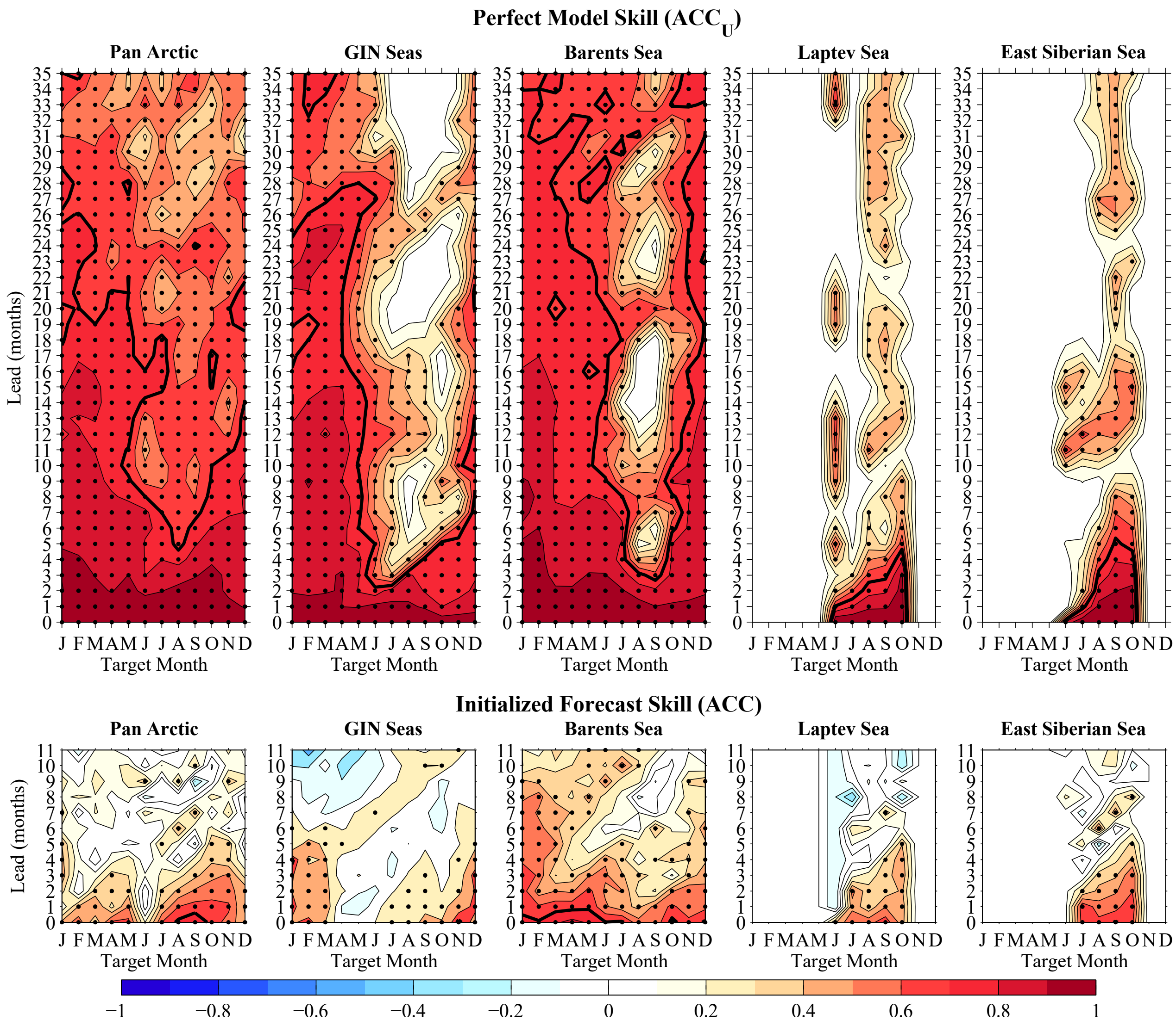




- Laptev and East Siberian Seas have spring prediction skill barrier: Predictions initialized May 1 and later are skillful; those initialized prior to May 1 are not
- Sea ice thickness initialization provides key source of summer prediction skill

Bushuk et al. 2017, *GRL*

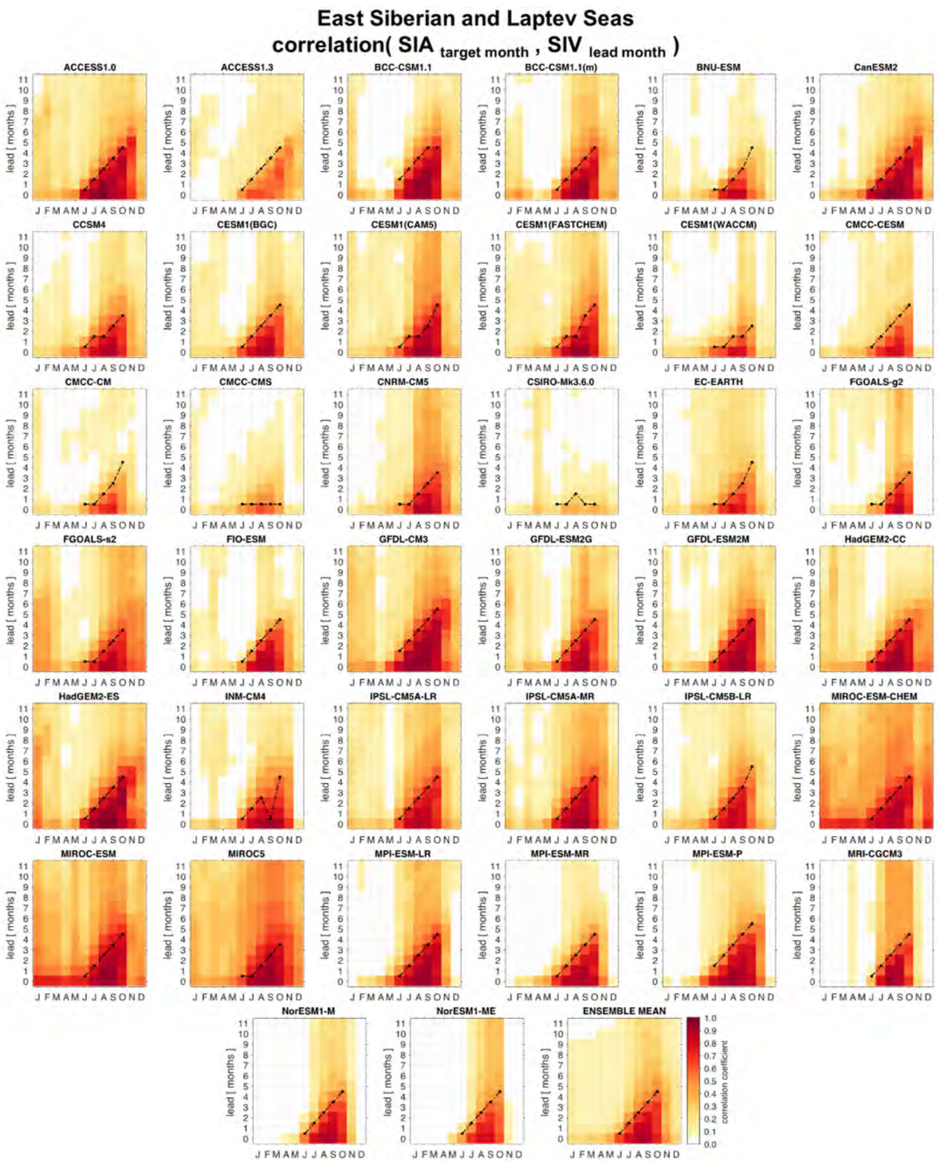
The Sea-Ice Prediction Gap: Comparison of Perfect Model and Real-time Prediction Skill



- Suite of perfect model experiments run with GFDL-FLOR provide direct comparison with initialized predictions
- Large skill gap between perfect model and initialized prediction skill
- Similar regional skill structure. Skill gaps related to errors in initial conditions and model biases

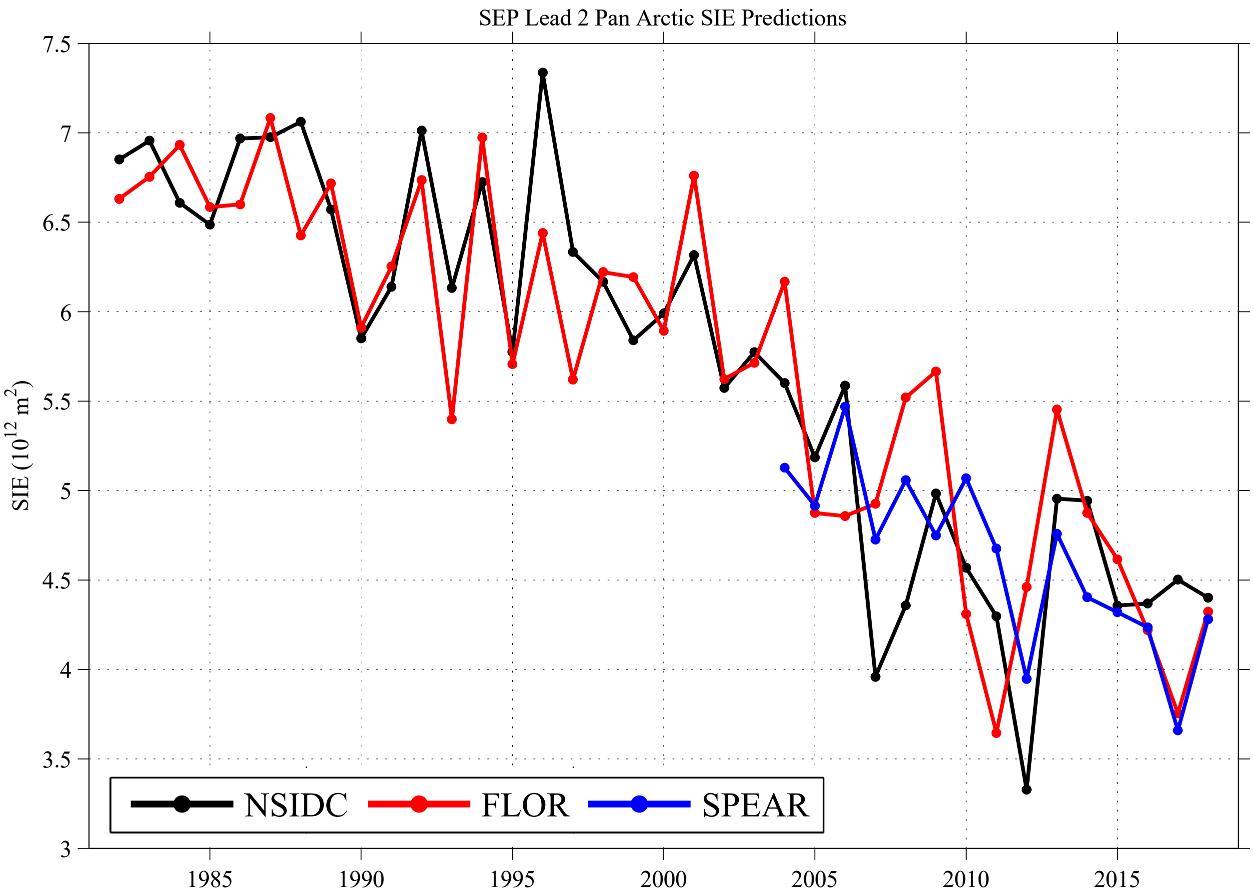
Bushuk et al. 2018, *Clim. Dyn.*

A Spring Predictability Barrier for Regional Arctic Sea Ice

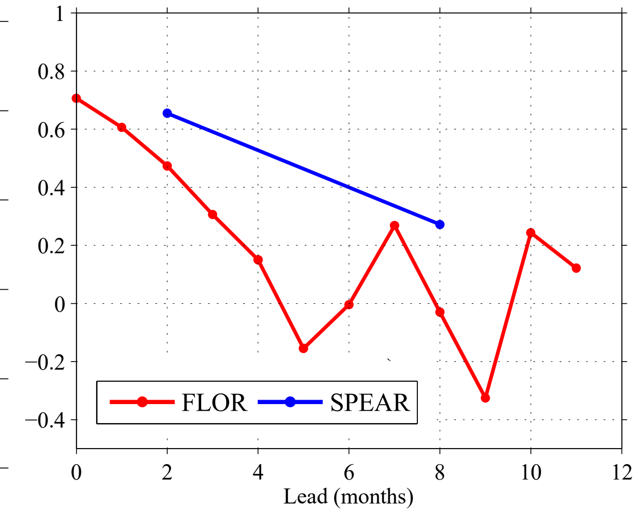


- A springtime predictability barrier for regional sea ice is a robust feature across CMIP5 GCMs
- There is a distinct diagonal feature — where correlation values drop off significantly after the month of May or June
- Satellite thickness data is only currently available until Mid-April. Need to extend thickness observations to June 1 to maximize benefit for seasonal predictions.

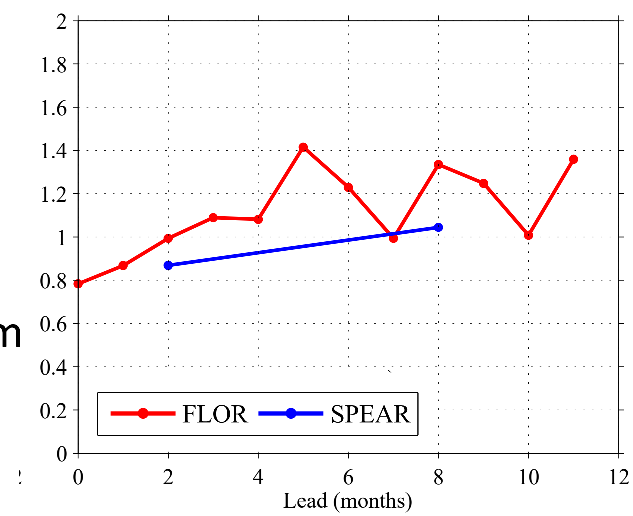
Preliminary results from SPEAR reforecasts



Detrended ACC



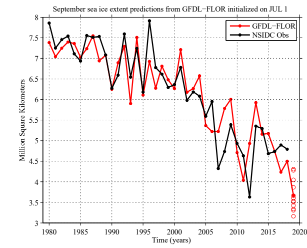
Detrended NRMSE



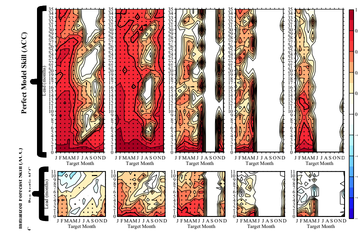
- Sea ice initial conditions from new SPEAR initialization system
- Prediction skill attributable to sea ice thickness initial conditions; may also benefit from atmospheric initialization

Summary

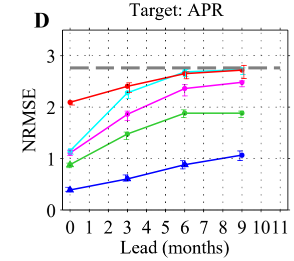
- GFDL-FLOR seasonal predictions skillfully predict pan-Arctic and regional sea-ice extent at lead times of 0-11 months depending on region and target month



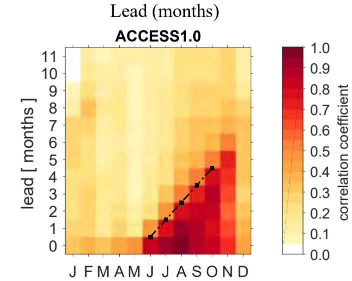
- Perfect model experiments suggest substantial skill improvements are possible in most regions



- Subsurface ocean heat content key source of skill for winter sea ice predictions. Assimilation of surface and subsurface ocean observations improves seasonal prediction skill.



- Sea ice thickness key source of skill for summer sea ice. Spring predictability barrier for regional summer predictions.



- Current work on sea ice data assimilation techniques, impact of sea ice model physics on predictability, and mechanisms of predictability